

Breakout: Terabits Networking Challenge - Backbone, MAN, and Campus Networking Agenda and Discussion Topics

Day 1: Breakout Session 1:

- Welcome and session logistics - Tom Lehman and Inder Monga
- Presentations:
 - Recent Advances in Network Systems - Drew Perkins
 - State of Packet Technology and Futures - David Ward
- Discussion of questions 1 and 2

Day 1: Breakout session 2:

- Welcome and session logistics - Tom Lehman and Inder Monga
- Presentation: Recent advances in flow switching and control – OpenFlow – Rob Sherwood
- Discussions of Question 2 and 3
- Summary of discussions - scribe

Day 2: Breakout Session 1

- Welcome and session logistics - Tom Lehman and Inder Monga
- Presentation: End-to-end network performance monitoring (TBD)
- Discussions on questions 3 and 4
- Summary of discussions - scribe

Day 2: Breakout Session 2:

- Welcome and session logistics - Tom Lehman and Inder Monga
 - Presentations:
 - ESnet Tabletop Testbed - Brian Tierney
 - GENI Project - Aaron Falk
 - Discussions on questions 4 and 5
 - Summary of discussions - scribe
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Session 1: Terabits Optical backbone, MAN, and Campus Networking Challenges

Context:

- Extreme Scale Computing- Toward Exascale computing
- Massive data sets – Estimated in Zetabyte-Scale
- Large-scale Collaborations and Real-time instrumentations
- Ease-of use and accessibility by scientists

1. **Question 1: Revisiting network fundamentals at extreme scale** - What are the fundamental technical challenges of scaling existing networks by 1000x in the core and 100x in the end systems to realized federated end-to-end terabits networking in the context of the flowing backbone networking concepts:

- a) Network architecture and protocols
- b) Packet-switching and circuit-switching
- c) Network provisioning and traffic engineering
- d) Federated network operation, control, and management
- e) Impedance mismatch between core network and end systems effective bandwidth

2. **Question 2: Multi-layer, multi-domain network provisioning** - The DOE operates a complex science environment consisting of science resources and national and international collaborators the generated distributed high-end science applications, each with unique network and cyber security requirements. What are the technical challenges of engineering multi-domain federated terabit network with differentiated capabilities to address the unique network requirements of different science applications in the following contexts?

- a) Multi-modal networking (packet-switching, dynamic, circuits, flow switching, etc.,) over a common federated terabits networks
- b) Multi-domain cross-layer optical network virtualization
- c) Inter-domain policy coordination and SLA for controlling and managing end-to-end dynamic circuits, virtual networks, network monitoring, cyber security, etc.
- d) others

3. **Question 3: Federated network services, management, and performance monitoring.** DOE network infrastructures is a complex collection of autonomous local, national, and international network systems that collaborate to deliver end-to-

end performance several order of magnitude higher than what commercial best effort IP internet offer What the challenges of development new network management and performance tools and service or scaling existing ones to take work efficiently in end-to-end federated hybrid terabits networks with cross-layer support. Critical factor for consideration:

- a) Multi-layer capabilities accessible by scientists at the application level and by network engineers the network layer 1-3
- b) Address inter-domain, access control, flow manipulation and control, policy coordination, etc., issues
- c) Predictive performance, real-time, post-Mortem, and x automated capabilities
- a) Other new control and management technologies

4. **Question 4: Testbeds and experimental network infrastructure** – Given that terabits networks will require new and sometime radically different networking architecture, protocols, hardware, software, etc., that could be disruptive to existing production networks; What the role and benefits of testbeds and experimental networking at scale in the development of end-to-end terabit networking? Issues of considerations:

- a) End-to-end testbeds addressing multi-layer, application prototyping, control plane, performance monitoring ,and inter-domains issues
- b) Coordination of multi-agency testbeds
- c) Simulation-based network experimentation that leverage petascale and exascale computing
- d) Accelerating advances in extreme-scale networking through industry and vendor partnerships in testbed and experimental partnership.

5. **Question 5: Extension of core network capabilities to end systems for massive data movement** – moving massive data generated by extreme-scale computing and large scientific instrument is a critical priority for DOE network infrastructures. What are the challenges of extending the abundant optical bandwidth made possible in the core by the emerging 100 GigE technologies to support the distribution of massive science data over very long distances? Potential issues for consideration:

- b) Transport protocols that can deliver 100x performance to high-end science application
- c) Harnessing parallel file systems features, multi-core host architectures, and I/O concurrencies to improve end-to-end data transfer throughputs
- d) Co-scheduling of network, storage, applications, etc., to maximize throughput and efficiency of data transfer

6. Other Questions